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16. ABSTRACT

The background and purpose of the Regional Air Pollution Study are outlined, together with the overall study design. To meet the objective of development and testing of improved air quality simulation models, an extensive and continuous set of pollutant and meteorological measurements, an emission inventory of high spatial and temporal resolution, and experiments to describe and quantify atmospheric dispersion, transformation, and removal processes were required. The required measurements and investigation carried out during the conduct of the study are summarized.

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Air monitoring milestones: RAPS' field measurements are in

The Regional Air Pollution Study in St. Louis provided a comprehensive documentation of regional air quality, meteorology, and pollutant emissions. RAPS involved an average data collection rate in excess of a million observations per day over a three-year period

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For a number of years, scientists in the field of air pollution and urban meteorology have recognized the need for a comprehensive study of an urban area in which all the interrelated processes affecting pollutant emission, dispersion, and composition, as well as the state of the atmosphere, could be investigated jointly. Additional impetus was provided for such an undertaking by the Air Quality Act of 1967 and the Clean Air Act Amendments of 1970. Specifically, in addition to other duties, the Congress charged the U.S. Environmental Protection Agency (EPA) with encouraging and assisting the development and operation of regional air pollution control programs.

This scientific inquisitiveness and Congressional mandate combined to produce the St. Louis Regional Air Pollution Study (RAPS), a major program of the EPA Office of Research and Development (ORD). The major objectives of the RAPS are:

- to develop, evaluate, and validate r quality simulation models AQSM) on a regional scale covering urban and rural stationary and mobile sources
- to develop, evaluate, and validate models of local-scale phenomena that complement regional scale models
- to create a comprehensive, accurate and readily retrievable data base for all criteria pollutants (sulfur dioxide, particulates, carbon monoxide, nitrogen oxides, oxidants, and hydrocarbons) and selected non-criteria pollutants for use in evaluating air quality simulation models

The verification and development of quantitative relationships between sources of pollution and ambient air quality measurements on the scale of an air quality control region will allow control actions to become more sophisticated and selective. General control actions can be confidently tested through these relationships to develop strategies for a region that provide the desired level of control for the lowest cost. The verification and development of such relationships will also allow impact on air quality to become a factor in community and industrial planning for future growth, and can be utilized to optimize the size of a monitoring network needed to define a region's air quality.

Study design

Thirty-three Standard Metropolitan Statistical Areas larger than 400 000 population were evaluated by the Stanford Research Institute in terms of pollutant backgrounds, heterogeneous emissions, existing pollution control programs, and climatic conditions.

On the basis of these criteria, the St. Louis Missouri/Illinois Metropolitan Area emerged as the site of the RAPS field measurement program. With an anticipated $25 million budget, the Interdepartmental Committee on Atmospheric Science (ICAS) requested the EPA to serve as the lead agency for the RAPS over a 5-y period. The first two years were devoted to planning, facility construction, and preparatory research. The major field measurement program began in mid-year of 1974 and concluded in June 1977.

The Air Monitoring Center of Rockwell International, Atomics International Division, was awarded a 2-y contract by the EPA in 1973 to conduct the RAPS. The follow-on contract was negotiated with Rockwell in 1975 to complete the field portion of the study. Assisted by subcontractors, Rockwell, as prime contractor was charged with establishment and operation of the routine RAPS air quality and meteorological measurement networks and the data handling facility.

Additionally, the prime contractor supported the RAPS research program by specialized atmospheric sampling, sample analysis, data processing, and data analysis. These specialized functions were conducted under a mechanism whereby individual Task Orders were issued as the need arose. Approximately 90 Task Orders were completed as part of the RAPS field measurement program. Additional RAPS participants included numerous universities, private research organizations, and other governmental agencies.

RAPS is structured as an orderly progression of efforts, partially simultaneous, but mostly consecutive. The first major step, the field measurement program, has been completed. This step was responsible for providing suitable types of measurements for the model evaluation and development.

Next is data management, made necessary by the sheer volume of data routinely obtained by the field measurement program. The final step consists of model evaluation and development, for example, the testing and verification of existing systems of simulation models and the development of improved models.

These three efforts are closely related and interdependent. Assumptions concerning the sources and atmospheric processes in the various models directed, through the data management step, the collection of

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data; analysis of the data collected will confirm or refute these assumptions, and may, in fact, disclose unexpected relationships that change the model structure.

The general design of the RAPS field measurement program consisted of both continuous measurements from a 25-station telemetering network to provide an extensive data base for model evaluation and development, and expeditionary studies to describe atmospheric processes to be incorporated as model modules or sub-models. Also included was a meteorological sounding network for upper air measurements.

RAMS

The Regional Air Monitoring System (RAMS) consisted of 25 remotely operated, automated stations controlled and polled via telemetry by a central data acquisition system. The locations of these stations were arranged in approximate rings with average radii from the central urban station (101) of 5, 11, 20, and 44 kilometers. Elevations of the stations were fairly uniform averaging 154 ± 23 meters above mean sea level.

Clustering the stations at the center of the network resulted from the criterion that site locations should depend on both pollutant concentrations and their spatial gradients, with the minimum spacing where the concentrations and gradients were highest. The four rural stations (122–125) at approximately 90° azimuth spacing were situated so as to provide background measurements regardless of the wind direction, coupled with a downwind counterpart. Other criteria for site selection included location at least one kilometer from any significant source, no horizon obstructions higher than one-tenth the distance from the wind sensors, and avoidance of topographic features capable of local wind flow influence. Table 1 presents a matrix of RAMS instrumentation by station.

Each of the 25 RAMS stations was equipped with a Digital Equipment Corporation PDP-8M minicomputer that sampled analog input from the instrument systems twice per second and status inputs once per minute. After forming one-minute averages for most parameters, these data were subsequently transmitted to the central computer facility over four leased telephone lines.

The station data acquisition system also routinely stored up to 48 h of one-minute data records on magnetic tape locally. In case of telecommunication interruption, these tapes were retrieved and read at the central computer facility.

The RAMS central computer facility consisted of Digital Equipment Corporation PDP 11/05, 11/35, and 11/40 processors, along with three terminals, on CRT display, disk-drive units, and tape-drive units. An electrostatic plotter, line printer, card reader, and paper tape reader/puncher

were also available for data input and output. The actual data collection operation was completely computer controlled under the guidance of a real-time monitoring software system.

This system handled the data communication of ambient measurements, display and storage, the system status and error checking, and the remote station controls. The basic data elements were checked and formed into hourly average values by the central computer, using daily zero and span calibration constants. Both the basic data and the hourly averages were then entered onto tapes that were sent to the EPA computer facility at Research Triangle Park, N. C., which serves as the central RAPS data bank.

Data quality assurance

The quality and integrity of the RAMS data were ensured through a dual quality assurance approach. Each data point was routinely checked by the central computer by comparing the datum, its rate of change with time, and variation from site to site, with an upper and lower bound associated with that measurement.

Additionally, the computer generated daily outputs that summarized the zero and span drift of each of the instruments. Either of these computer checks was capable of generating an error code so that an investigation, and possibly corrective action, could be taken.

The second type of quality assurance activity consisted of qualitative and quantitative audits and calibration standards verification by the prime contractor, by the EPA staff, and by independent contractors. A mobile calibration van operated by Rockwell personnel performed audits of selected RAMS stations, local pollution monitoring networks, and analyzers used by principal investigators during expeditionary studies.

Under contract to the EPA, the Research Triangle Institute conducted four independent performance audits of RAMS sensors. These point-in-time audits were designed to provide estimates of measurement precision and bias.

Upper Air Sounding Network

While the RAMS network provided a relatively comprehensive description of surface winds, temperature, and relative humidity across the urban area, the Upper Air Sounding Network (UASN) was operated to provide a data base of the upper air structure over the St. Louis region, particularly as it related to terrain features and synoptic scale meteorology. Hourly meteorological soundings were routinely performed five days per week at two sites, one urban (141) and one rural (142).

These soundings included radiosonde ascents to obtain wind, temperature, and humidity measurement at 6-h intervals, with the hours of release being seasonally adjusted so that the first radiosonde each day was released during the hour preceding sunrise to measure maximum stability. Pilot balloons were visually tracked at intervening hourly intervals to obtain wind measurements only.

During the expeditionary periods each year, the UASN operation was expanded spatially by the addition of two more rural sites (143 and 144), and temporally by converting to seven-day-per-week operation at all four sites. During the field measurement program of RAPS, the UASN produced approximately 5700 radiosondes and 29 500 pibals, with an achievement rate exceeding 98% of scheduled pibals and 99% of scheduled radiosondes. Virtually all missing observations were associated with prohibitive weather conditions.

Radiosonde and pibal data underwent extensive manual quality assurance by the contractor's UASN staff before being submitted to the RAPS data bank for keypunching, computer reduction, and further quality assurance checks. Current UASN analyses include determination of mixing depths, transport winds, and ventilation factors from the radiosonde data and construction of three-dimensional wind fields from the combined RAMS/pibal/radiosonde wind measurements.

Expeditionary investigations

Two or three expeditionary investigations were conducted each year as part of the RAPS field measurement program. These four-to-five-week ex-

TABLE 1
Regional Air Monitoring System (RAMS) instrumentation by station

	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125
O_3, Monitor Labs 8410	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
NO, NO_x, Monitor Labs 8440	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
CO, CH_4, THC, Beckman 6800	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
TS, SO_2, H_2S, Tracor 270HA	x		x	x	x	x		x					x	x	x	x				x	x	x			
TS, Meloy SA 185		x					x		x	x	x	x						x	x				x	x	x
Visibility, MRI 1561	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Wind speed, MRI 1022 S	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Wind direction, MRI 1022 D	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Temperature, MRI 840-1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Dew point, Cambridge 880	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Temp. gradient, MRI 840-2	x	x		x	x	x	x		x		x	x	x									x	x		
Barometer, Soetman 383	x								x			x										x	x	x	x
Solar radiation (Eppley) Pyranometer			x	x				x						x				x				x			
Solar radiation (Eppley) Pyrheliometer			x											x				x				x			
Solar radiation (Eppley) Pyrgeometer			x											x				x				x			
Turbulence, R. M. Young 27002					x		x		x		x		x												
Gas bags, Xonics	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Hi-Vol, Sierra 305			x		x	x		x				x			x			x		x		x		x	
LBL dichotomous sampler			x		x	x		x				x			x			x		x		x		x	

peditions were designed to supply short-term, detailed atmospheric observations in support of the validation and development of relationships between pollutant sources and ambient air quality.

These expeditionary investigations can be divided into four major categories:

- pollutant transport and dispersion
- pollutant transformation and removal
- pollutant measurement
- RAMS vertical extension.

The pollutant transport and dispersion study was a series of experiments directed toward understanding and subsequently describing the relationships between atmospheric, dynamic, kinematic, and energetic processes that occur in the urban boundary layer and their resultant impacts on the transport and dispersion of pollutants. Of particular interest was the effect on the boundary layer of the widely varying thermal and mechanical properties of the urban surface.

Components of this study included a detailed description of the temporal and spatial variability of the urban boundary layer structure by means of instrumented aircraft and surface vehicles, airborne and surface-based lidars, mobile radiosonde and pilot balloon teams, an acoustic echo sounder, and laser anemometers. Vertical fluxes of momentum, sensible heat and moisture were investigated by using measurement platforms at four levels; instrumented aircraft, tethered balloon and tower measurements, surface-based instrumentation, and sub-surface temperature sensors, with the experiments repeated over several types of urban and rural surfaces.

Land-use types, as determined by satellite imagery, were studied to determine the spatial distribution of surface albedo and thermal emissions across the urban area. These surveys were augmented by RAMS radiation sensors and by aircraft fitted with upward and downward sensing pyranometers and pyrgeometers to define the solar and long-wave radiant energy balance over selected land-use types. Finally, sulfur hexafluoride (SF_6) tracer released were performed from tall stack sources in the St. Louis region, in an attempt to quantify vertical pollutant distribution during unstable periods.

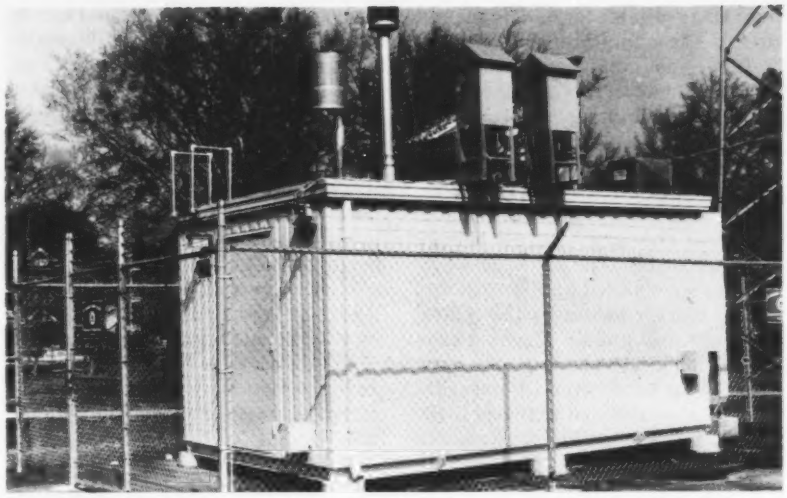
The focus of the pollutant transformation and removal study was on oxides of sulfur, with much of the experimental work devoted to the dynamics of aerosol formation. In the point source component of this study, oxides of nitrogen, oxides of sulfur, and ozone, together with the spectrum of aerosol size, were sampled at increasing travel times from the sources to determine transformations occurring within relatively high pollutant concentrations.

Similar studies of the complete mix of pollutants in the plume from the whole urban complex were conducted along with measurements of hydrocarbons, carbon monoxide, and oxidant. Equipment utilized in both the point source and urban activities included various instrumented aircraft, a surface-based correlation spectrometer, airborne and surface-based lidars, SF_6 tracer releases, and mobile pilot balloon teams.

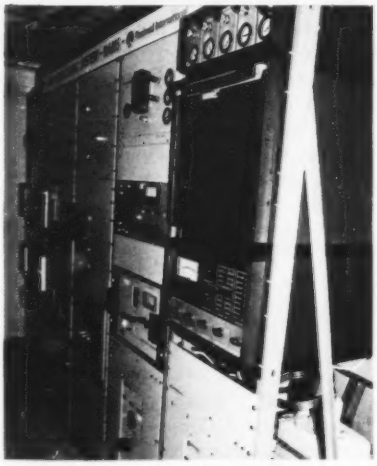
Light microscopy and infrared analyses of fractionated aerosol samples were performed subsequent to airborne activities. Two mobile laboratories, each with a computer-based data acquisition system, measured the St. Louis aerosols in terms of their physical and chemical properties to determine their probable origins and evolution.

As another phase of the pollutant transformation and removal study, photochemical reactions were determined by periodically measuring changes that occurred in captive bag samples during irradiation by either sunlight or artificial means. Similar surface and airborne samples underwent gas chromatographic analyses for C_1 through C_{10} hydrocarbons, total hydrocarbons, carbon monoxide, and nitrogen oxides, as part of the hydrocarbon characterization effort.

In addition to the high volume and dichotomous samplers operated at the RAMS stations, particulates were collected by means of streaker samplers and impactors to provide elemental distribution according to particle size. SO_2 deposition flux measurements were conducted, using an experimental technique based on the flux/gradient method, in which vertical concentration profiles of SO_2 and turbulence parameters were combined

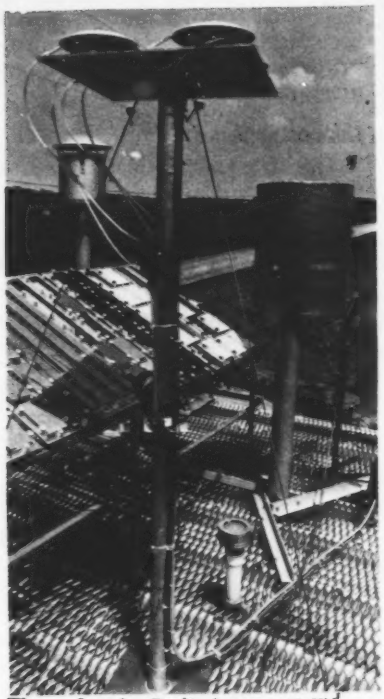


On the roof. *RAMS station with hi-volume sampler & materials exposure rack*

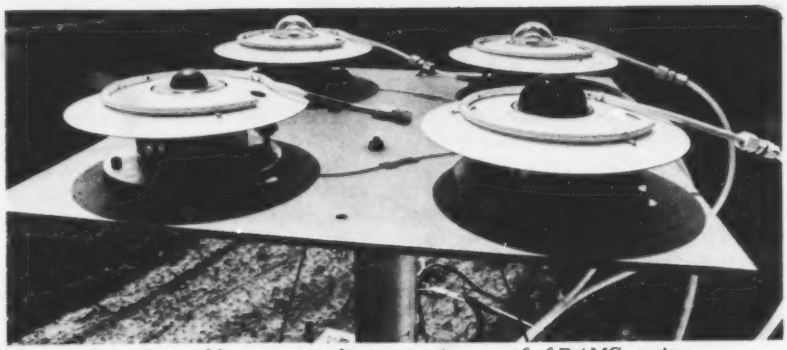


Inside. *Instrument rack in station*

On the ground. *A weather Radiosonde*



The roof again. *Radiation sensor and materials exposure rack*



Sensors. *For solar and long-wave radiation, again on roof of RAMS station*

In the air. *Helicopters equipped to measure same parameters as RAMS station*

to estimate vertical turbulent flux of SO_2 within the surface boundary layer.

Evaluation of instruments

The RAPS, based upon the best available monitoring instrumentation at the time of its design, provided an excellent opportunity to test new instruments and techniques for monitoring air quality under the pollutant measurement program. Comparison with RAMS measurements and with other appropriate standards enabled evaluation of such monitoring systems as a nitrogen dioxide laser-induced fluorescence monitor, a beta gauge particulate monitor, and a laser system for measuring carbon monoxide, ozone, nitric oxide and ammonia. Also tested were sulfuric acid monitors, dichotomous samplers, and various aerosol sampler systems.

A second component of the pollutant measurement program was a variability study to quantitatively assess the spatial representativeness of the RAMS air quality and meteorological observations over a one-kilometer square grid employed by most mathematical simulation models.

Pollutant variability was measured by means of longpath monitors such as laser systems and correlation spectrometers, and by point monitors carried either by person or vehicle. Meteorological variability was evaluated utilizing a mobile van traversing specified one square kilometer areas around RAMS stations having different land use patterns, each composed of relatively homogeneous aerodynamic roughness.

Use of helicopters

Routine surface air quality and meteorological measurements were augmented during the expeditionary investigations by the use of two instrumented EPA Sikorsky helicopters. These helicopters were equipped with monitoring systems to procure values of the same parameters as measured by the RAMS network; components of the system are listed in Table 2.

Daily flights, consisting of a sequence of soundings over selected RAMS stations, were performed to provide a vertical extension of the fixed network with the ultimate goal of constructing three-dimensional depictions of pollutant distributions in the urban boundary layer. Preselected flightpaths were chosen so that for any given wind direction, aerometric soundings would be made over six to eight RAMS stations in a roughly elliptical overall flight pattern.

Additional flights were frequently performed to complement the data being collected during the expeditionary periods by other airborne and surface-based monitoring systems. Equipment calibrations were performed before and after each flight accompanied by review of the data tapes for system malfunctions. Calibration constants were applied during the editing process before submission of the tapes to the RAPS data bank.

Cooperative studies

RAPS data were exchanged with participants in related studies who chose the St. Louis Metropolitan Area as a base of operations. Preceding RAPS in the St. Louis area was the Metropolitan Meteorological Experiment (METROMEX), a joint research venture involving groups from Argonne National Laboratory, Battelle Pacific Northwest Laboratories, University of Chicago, Illinois State Water Survey, NOAA Wave Propagation Laboratory, Stanford Research Institute, and University of Wyoming. METROMEX investigators performed field studies during 1971–1975 to study the effects of the St. Louis urban environment upon precipitation patterns and related severe weather.

The Midwest Interstate Sulfur Transformation and Transport (MISTT) study was conducted in the St. Louis area during 1975–1976. Funded through an interagency energy/environment research and development program, this EPA project was responsible for activities previously described in the pollutant transformation and removal study.

Another EPA-sponsored project was a materials exposure study utilizing nine of the RAMS shelters. Spec-

imens of paint, steel, marble, silver, aluminum, and nylon were exposed for varying periods of time, some under tensile stress. Possible cause-effect relationships were investigated by statistically analyzing the effects data and corresponding air quality measurements.

RAMS air quality data were provided to St. Louis University for correlation, with health effects being monitored under pulmonary studies of asthmatics, postal workers, and gardeners. Similar data were provided in support of the Harvard University epidemiological study of respiratory health effects being conducted in south St. Louis. A Department of Transportation highway emissions study was another recipient of supportive RAMS air quality and meteorological data.

The RAPS cooperated with the DAVINCI II and III flights during the summer of 1976. Project DAVINCI was a scientific manned-balloon program designed to investigate the behavior of air pollutants on a time scale of days and on a distance scale of hundreds of kilometers by drifting along with the polluted air mass.

These flights were conducted by Sandia Laboratories under the combined sponsorship of ERDA, NOAA, EPA, and the National Geographic Society.

Emission inventories

The final major division of the field measurement program consisted of the emission inventory effort. The accuracy of any attempt to predict air quality through regional air quality simulation models is proportional to the overall accuracy of these inventories. Hence, a parametric study was conducted to determine the most desirable characteristics of an emission inventory gathered for research purposes.

The initial thrust was to develop a detailed point source inventory for sulfur dioxide based on hourly, measured values. The distribution of sources in the St. Louis region made this technically feasible since a relatively small number of large sources, each emitting more than 1000 tons annually, accounted for well over 90% of all SO_2 emissions. The remaining small sources were aggregated into area sources and emissions were estimated from such parameters as the consumption of fuel within the specified area.

A motor vehicle emission inventory was also developed, composed of line and area sources. Well-defined and heavily traveled traffic arteries, such as highways, were treated as individual line sources, whereas the more diffuse traffic on city streets was best handled on an area basis.

As RAPS progressed, inventories for other pollutants were added coincident with the period of RAMS operation. At present, the following emission inventories are available for the St. Louis area:

- hydrocarbon
- organic
- non-criteria pollutant
- sulfur compounds
- particulate size distribution
- fugitive dust
- heat

Inventories classified by source types include residential and commercial, river towboat, airport, rail, and off-highway mobile (lawnmowers, construction equipment, etc.). Contents of the emission inventories have been verified by using precision analysis techniques and a quality assurance program.

TABLE 2
RAPS helicopter instrumentation

Parameter	Method and instrument
NO, NO_x, (NO_2 by subtraction)	Chemiluminescence ($NO + O_3$) (TECO 14B)
O_3	Chemiluminescence ($O_3 + C_2H_4$) (REM 612)
CO	Non-dispersive infrared (Andros 7000)
SO_2	Flame photometry (Meloy SA160)
Total hydrocarbons, methane (Nonmethane hydrocarbons by subtraction)	Flame ionization (MSA 11-2)
Particles (visibility)	Nephelometer (Light scattering) (MRI 1550)
Particle size	Optical (Royco 220)
Temperature	(Cambridge CS ;37)
Dew point	
Location	Doppler radar
Altitude	Barometric pressure
Bag samples (Tedlar)	Gas chromatography

Data management

The data management function served as a bridge between the model development and the field measurement program to ensure the interaction between field-oriented activities and data utilization. This function had to be responsive to user requirements within the framework of RAPS objectives while simultaneously maximizing data integrity and minimizing the impact on computer resources.

These requirements led to the development of efficient storage and retrieval software, simple on-line display and analysis capabilities, timely distribution of data in user-specified formats, periodic data-base summary reports, and adaptability to changing needs and schedules. The heart of the RAPS data base is a UNIVAC 1110 computer located at Research Triangle Park, utilizing MRI System 2000 data management language.

The RAPS involved an average data collection rate in excess of one million observations per day over a period of about three years. In addition to routine processing of this vast amount of data, the data management component developed validation criteria based on physical, meteorological and air quality relationships, instrument capabilities and specifications, and within-station and across-network data comparisons.

The RAPS concept of data validation employed a scheme of flagging data, which failed to meet established criteria. In all cases where such questionable data were flagged as invalid, the original data were preserved for possible later use by an investigator.

Model evaluation & development

The major thrust of RAPS is the evaluation of existing mathematical simulation models, using regional air quality, meteorological, and emissions data obtained during the field measurement program. Development of new models, while important particularly in the areas of pollutant transformation and removal, is of secondary priority in RAPS. Furthermore, emphasis has been placed upon deterministic, physically-based relationships between emissions and ambient air quality in preference to predictive formulations.

The modeling effort is being conducted by and under contract to the Meteorology and Assessment Division of the Environmental Sciences Re-

search Laboratory at Research Triangle Park. Although several models have been adapted to the St. Louis region, testing of these models necessarily had to await results of the field measurement program.

Potential candidate models to be tested can be divided into two principal categories. The first is the superimposed plume model in which the contribution of concentration from any one source is independent of the contributions from all other sources, so that one can simply add all the individual contributions to obtain the total concentration at a point.

These models commonly use the assumption of a Gaussian distribution of pollutant concentrations in the cross wind and vertical directions, with modifications for the effect of a depth limit through which mixing occurs. Superimposed plume models can partially incorporate parameterization of some reaction processes by use of an assumption of simple first-order reactions, which may either remove or generate pollutants.

The second type of model formulation is the grid-point. The spatial resolution of such a formulation can be made as coarse or fine as desired. However, since the required computer capacity varies as the square of resolution, practical limits on resolution exist for any such formulation. The advantages of grid-point models lie in their capability to incorporate processes more complex than simple first-order reactions. Both dry and wet deposition processes can be included, as can pollutant reactions of any desired degree of complexity. Further, the effects of the varying surfaces on the boundary layer structure and on the turbulent exchange rates of the overlying air can be defined. Temporal variations are readily incorporated into grid-point formulations.

Grid-point models that may be developed for RAPS will include transformation and removal processes in as highly parameterized forms as possible, based directly on results of field and laboratory studies. For atmospheric reactions, grouping of approximations may take the form of omitting species or reactions, grouping of species, omission of intermediate reaction steps, etc.

For dry deposition on surfaces, an *effective deposition velocity* will be derived insofar as possible from direct measurements over simple homogeneous surfaces with adjustments for more complex surfaces. The mean boundary layer atmospheric structure will be derived by interpolation and extrapolation of direct wind and temperature measurements, but diffusion rates must still be expressed in highly parametric form, depending both on the mean wind and temperature profiles as well as on the types of underlying surface over which the air flows.

Tangible benefits of the RAPS program

- The RAPS produced the most sophisticated, comprehensive, real-time air quality and meteorological monitoring network in existence. This involved reliance on advanced concepts for developing air quality instrumentation, calibration and quality assurance procedures, and a real-time data reporting system.
- The quality and integrity of the RAMS and UAM data bases are unsurpassed; both meet the objectives and goals of the RAPS.
- The RAPS has produced superior urban air characterization investigations, using mobile platforms.
- The RAPS has produced local pollutant variability studies that provide new insight for site selection criteria.
- The RAPS has produced one of the most comprehensive and source-tested urban emission inventories available and, in the process, developed new and important methodologies for inventorying pollutant emissions.
- The RAPS has produced an operational, computerized graphics system capable of using all EPA standard data terminals.
- The RAPS has stimulated development of specialized instrumentation such as the diode laser, the dichotomous sampler, and the gas filter correlation monitor for carbon monoxide.

While the models to be developed and validated under the RAPS program are intended to permit reasonable decisions to be made concerning source control strategies and their associated costs, there are many other potential applications that may use these models either directly or with small modifications. Substitution of concentrations calculated from models for direct measurement of concentration has long been recognized as a fundamental benefit of air quality simulation models. While RAPS is designed basically as a research study, the eventual application of models to determine compliance with air quality standards is already a reality; the benefits of technically credible models alone is considered to justify the cost of RAPS.

The potential uses of models in effects studies such as health, ecological, and economic, deserve attention. If, as expected, RAPS models demonstrate a reasonable degree of success in calculating concentrations of diverse pollutants, primary and secondary, then substitution of models for measurements in such studies will receive justification and support. Strengthening the atmospheric model link between sources and concentrations at receptors in more general ecologic and economic models will permit focus on other aspects of these models, which are even less clearly defined than the atmospheric link.

Additional reading

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